BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images may include (but are not limited to):

- BLACK BORDERS
- TEXT CUT OFF AT TOP, BOTTOM OR SIDES
- FADED TEXT
- ILLEGIBLE TEXT
- SKEWED/SLANTED IMAGES
- COLORED PHOTOS
- BLACK OR VERY BLACK AND WHITE DARK PHOTOS
- GRAY SCALE DOCUMENTS

IMAGES ARE BEST AVAILABLE COPY.

As rescanning documents *will not* correct images, please do not report the images to the Image Problem Mailbox.

PCT/IE 00/00106

10/070742

IE 00/106

Patents Office
Government Buildings
Hebron Road
Kilkenny

4

I HEREBY CERTIFY that annexed hereto is a true copy of documents filed in connection with the following patent application:

Application No.	S990765
Date of filing	13 September 1999
Applicant	COMMERGY TECHNOLOGIES LIMITED, an Irish company of 133 Lansdowne Park, Ballsbridge, Dublin 4, Ireland.

PRIORITY DOCUMENT

SUBMITTED OR TRANSMITTED IN COMPLIANCE WITH RULE 17.1(a) OR (b)

Dated this 23 day of October, 2000.

Richard O'Callaghan

An officer authorised by the
Controller of Patents, Designs and Trademarks.

5. Statement of right to be granted a patent (Sec

6. Items accompanying this Request

(i) [X] prescribed filing fee (IRP 50)
(ii) [ ] specification containing a descripti
[X] specification containing a descripti
[X] Drawings referred to in description
(iii) [ ] An abstract
(iv) [ ] Copy of previous application(s) whos claimed
(v) [ ] Translation of previous application priority is claimed
(vi) [ ] Authorisation of Agent (this may be below if this Request is signed by t

7. Divisional Application(s)
The following information is applicable to the pre which is made under Section 24 -

Earlier Application No.
Filing Date:

8. Agent

The following is authorised to act as agent in connected with the obtaining of a patent to whi relates and in relation to any patent granted -

Name & Address

Cruickshank & Co. at their address recorded for t the Register of Patent Agents is hereby appoi address for service, presently 1 Holles Street, D

9. Address for service (if different from that at

Signed Cruickshank & Co.

By:- Executive.

Agents for the Applicant

Date September 13, 1999.

increase with temperature. This reduction in operating temperatu
achieved by coupling the components to an external heat sink usi
conductive and electrically-insulating materials. This heat sink dis
convection, either natural or using forced air or other fluid, and is t
metal with multiple fins in order to achieve a high value of surface
the cooling air or other fluid. Many modules of this type are const
base-plate which can be easily mounted in close thermal contact
sink. An implementation using this approach is as described in U
Specification 5075821 (Donnel.).

Given the requirement for close packing of printed circuit "cards" i
there is a requirement for low-profile power conversion modules.
mounted above the module adds to the effective profile of the mo
attached to the sides of the module reduces the effective area ava
of components on the printed circuit "card".

The requirement for external heat sinks (without having to reduce
capability of the converter module) may be reduced or eliminated
efficiency of the module and/or by improving the thermal design o
its interface with the printed circuit "card" on which it is mounted.

A number of techniques is available to improve efficiency, and imp
efficiency are facilitated by continuing development of power semi
with higher performance in terms of lower conduction and switchir
devices allow synchronous rectification of the outputs from a trans
devices, used as synchronous rectifiers, can achieve a very much

Statements of invention

According to the invention there is provided a printed circuit board ass
comprising a plurality of heat generating thermally conductive compon
the board characterised in that at least two of the components are th
thermally conductive elements.

Ideally the components with different heat dissipating properties and/or h
outputs, in use, are linked.

Preferably the components having high heat generation also have high s
allowing for efficient heat dissipation. The overall profile of the board is c
minimum possible having regard to the highest components being used
the board and in which heat dissipation elements such as heatsinks are
components while not increasing the overall profile of the board.

A particularly advantageous construction arrangement may involving pla
component with high heat generation on the opposite side of the board fi
with high heat dissipation capability (i.e. low thermal resistance) and ach
coupling between the two.

Ideally thermal vias are incorporated in the board, or alternatively the cc
thermally connected by pins having a high thermal conductivity.

In one embodiment of the invention there is provided a DC to DC conve
input devices, a transformer, rectifiers and output inductors forming high

Alternatively, if the bottom face of the board is to be conduction-coc printed circuit "card" on which it is mounted, then the output rectifier below the board may provide an element of cooling for the magneti above the board.

Detailed Description of the Invention

The invention will be more clearly understood from the following de embodiment thereof, given by way of example only described with accompanying drawings in which:

Fig. 1 is plan view of a DC to DC converter according to the

Fig 2 is a side view of the DC to DC converter of Fig 1, and

Fig. 3 is a plan partially diagrammatic view of an inductor u of Fig. 1 and 2.

Referring to the drawings and initially to Figs. 1 and 2, there is pro converter indicated generally by the reference numeral 1 having a 2 incorporating thermal vias formed by holes 3. Mounted above th board are input switches 4 which are mounted above the board 2 a covered by a heat sink 5. Input capacitors and controls 6 which ar consuming devices are typically mounted below the board 2. Also board 2 and not shown in any detail is a transformer 7 and output

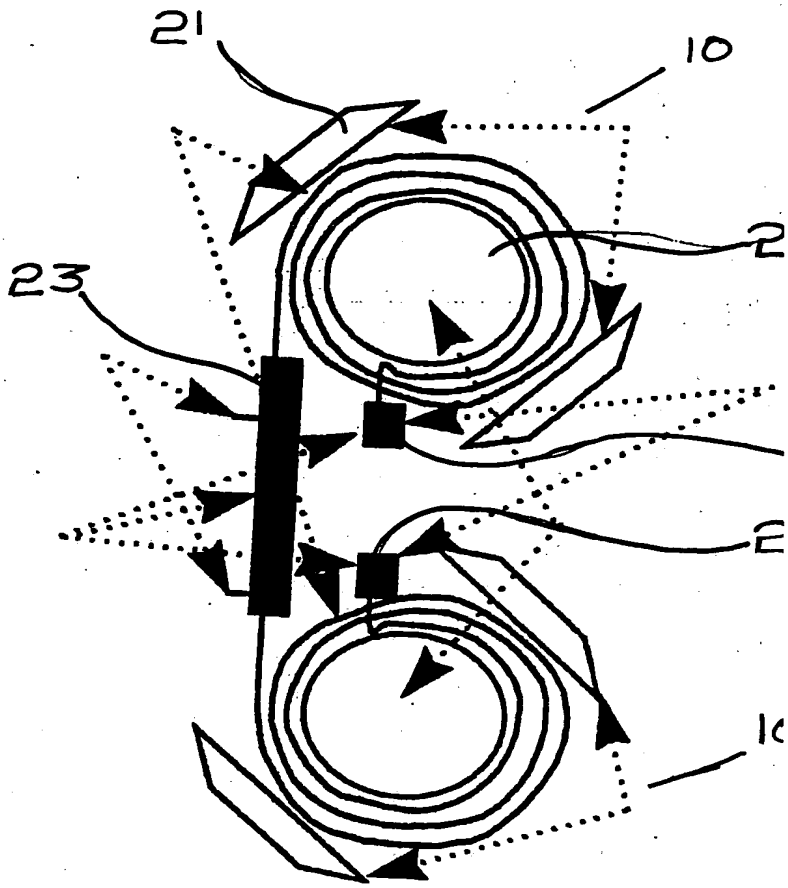
between the windings and the magnetic materials. This may be achi
layer of conformable thermally-conductive but electrically-insulating r
GapPad™ from Bergquist Corporation) between the wire or planar w
and the inner faces of the ferrite material, as an alternative to use of
conductive adhesives or to potting of the magnetic assemblies.

It will be appreciated that ferrite materials typically have thermal conc
range of 4 to 7 WmK^{-1}. Ferrite assemblies can thus serve effectively
themselves for components thermally coupled to them.

In this implementation, the ferrite elements are thermally coupled by
sheet (and/or adhesive) of material 14 to the synchronous rectifying e
are mounted below the board. This mounting approach allows the sy
rectifying elements typically in small surface-mount packages less tha
mounted with wide spacing across the printed circuit board within the
avoiding "hot spots". With currently available planar magnetic structu
allows the overall module height to be constrained to the range of 10
which is preferred in order to achieve overall dimensional requiremer

Further heat-sinking for such synchronous rectifying elements is achi
wide pins to connect the board on which such elements are mounted
(planar or conventional) used in the transformer and output inductors

A further development involves use of the printed-circuit card on whic
mounted as part of the heat-sinking design. The module typically is r


21
10
2
23
E
1

planar magnetic element 20 and the surface mount package which is important in many applications.

Referring now to Figs. 2 to 4 the planar magnetic element 20 comprises a magnetic core material 25 in one or more sections and typically also incorporates a printed circuit board 26 which carries tracks in the form of windings or access terminators for wire based windings. The printed circuit boards 26 carry plugs 27 for mounting in upstanding sockets 28 on the printed circuit board 2. It will be seen therefore that the planar magnetic element 25 is mounted in spaced apart relationship with the printed circuit board 2 and thus provides gaps or spaces for components. Obviously lower profile components must be mounted below the inner magnetic core material sections and other components may be placed in other portions. It is envisaged that the planar magnetic element may incorporate conformable electrically insulating and thermally conductive material 29.

An important aspect of this assembly is that the planar magnetic element 20 is easily pluggable into the printed circuit board 2. This is an important design consideration in many applications.

The term 'conformable' means that the material will generally conform to the irregularities of for example a printed circuit board. The GAP PAD material provides efficient heat transfer from the surface of a printed circuit board which may have some variations in solder thickness or other non-uniformities on the surface. Also it will be appreciated that the manufacturing process may require that one or more of the printed circuit boards be passed initially to a wave soldering process.

This would be particularly the case with the main printed circuit board in order to fill the vias with solder prior to application of for example surface mount devices which, in turn, may involve a reflow process. A thermally conductive substrate may be used for the main printed circuit board. It will also be appreciated that selective use of a thermally conductive and electrically insulating conformable material will allow devices at different electrical potentials to use the same heat dissipation material joined together. For example, the selective use of this approach covering all of effectively the heat sink with insulating material but having selected areas of heat spreaders topped by, for example, a conformable material such as that sold under the Trade Mark GAP PAD allows for the transfer of heat from surface mount devices to the reverse side of the board or heat sink side of the board. It will also facilitate the use of through hole components in those areas removed for example from heat spreading plates and the like. It is also possible to ensure that isolation gaps can be maintained between heat spreading grounded to the input side and those grounded to the output side and any relevant component.

It is envisaged that the overall assembly by clamped or otherwise secured so that some compression force is maintained on relative sections of the conformable material.

One of the advantages of the construction according to the present invention where planar magnetic elements are stacked above surface mounted devices is it creates the opportunity for thermal coupling between the planar elements and the power devices. It will be readily appreciated that the thermal conductivity in ferrites and other magnetic elements can be such as to achieve improved cooling particularly

under transient conditions of the semi-conductor devices. It will be appreciated that the thermal conductivity in most ferrites is of the order of 4W/mK to 7W/mK. Used in a planar magnetic structure with large ferrite cross-sectional area this level of thermal conductivity can be sufficient to achieve some material reduction in temperature of attached or adjacent semi-conductor devices. It will be appreciated that the overall thermal resistance of the assembly will of course be materially lower than that of the ferrite alone because the effect of the endpieces, spreading between the upper and lower of the pieces and of the thermal conductivity of the winding section in the planar magnetic device. The magnetic material will facilitate the transfer from the semi-conductor devices to any additional heat sinks for example located adjacent to the planar magnetic device.

The further advantages of this construction is that the planar magnetic elements may also provide electrical screening since grounding of the magnetic material which typically has a moderate level of electrical conductivity will achieve this.

It is envisaged that thermal conductivity to the planar magnetic assembly may also be facilitated by the use of a conformable material such as that sold under the "Gap Pad" Trade Mark to improve thermal conductivity between the winding and the magnetic comb material on one or indeed more likely both faces. This can reduce the overall thermal impedance between the faces of the planar magnetic components.

It will be also be appreciated that in many cases operating the magnetic material in a planar magnetic component at an augmented temperature may give improved

performance with lower losses in the magnetic material albeit somewhat offset by higher losses in conductors. In this case thermal coupling between a semiconductor devices and a planar magnetic assembly is advantageous for the overall performance of the circuit.

It is also envisaged that in certain instances it may be advantageous for the planar magnetic structure to be mounted so that the magnetic elements are almost flush with the main printed circuit board and that that part of the winding structure not covered by the magnetic elements be used for heat transfer. A further variation in this approach would be for the planar magnetic assembly to be used in association again with some conformable electrically thermally conductive and electrically insulated material. It is equally possible to transfer heat from components mounted below the main printed circuit board with heat conducted to the upper face of the printed circuit board by means of the via holes or by means of thermally conductive substrate material incorporated in the main printed circuit board. It is also envisaged that by the use of the structures there may not necessarily be a need to have any lower heat sinks or associated layers of thermally conductive material as shown. It is also envisaged that instead of conformable thermally conductive material that this may be replaced by a rigid material possibly with a covering of grease or phase-change material if relative flatness and co-planarity of adjoining surfaces can be guaranteed within close tolerances.

The use of the planar magnetic element positioned near or over heat generating devices acts as a natural heat sink for the heat generating devices. This is due to the fact that the planar magnetic element have associated with each ferrite core which

have heat dissipative properties depending on the type of ferrite used.

In some cases it may be desirable to have a gap or some separation between the planar magnetic elements and the heat generating elements, in which case the conformable electrically and thermally insulating material may be used between the planar magnetic elements and the heat generating semi-conductor elements. Then if an additional heat sink is to be provided such a heat sink would be utilised entirely for heat dissipation in the planar magnetic element.

It will be appreciated that by applying the conformable electrically insulating and thermally conductive material beneath the printed circuit board that extremely efficient heat dissipation may be achieved.

In the specification the terms "comprise, comprises, comprised and comprising" or any variation thereof and the terms "include, includes, included and including" or any variation thereof are considered to be totally interchangeable and they should all be afforded the widest possible interpretation and vice versa.

The invention is not limited to the embodiment hereinbefore described, but may be varied in both construction and detail.

CRUICKSHANK & CO.

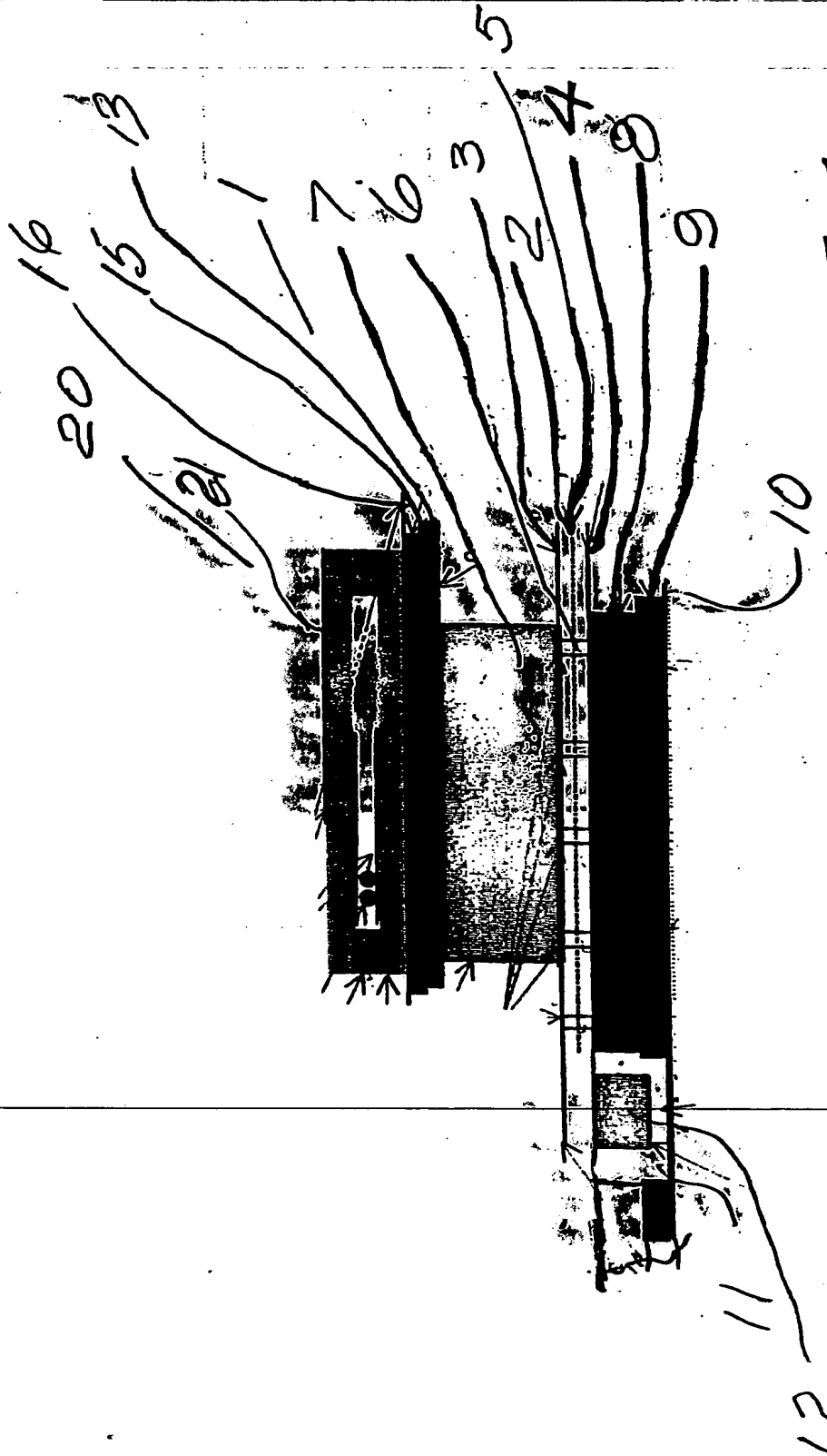


Fig 1

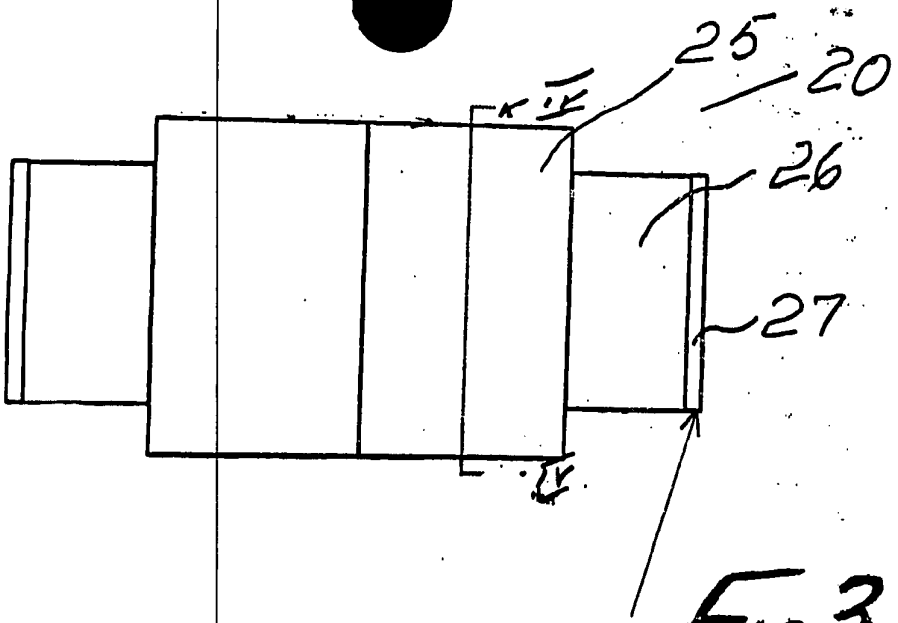


FIG 3

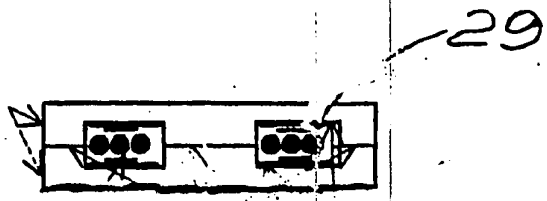


FIG 4

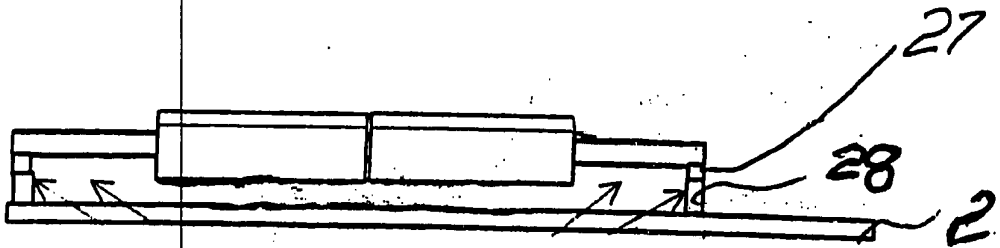


FIG 2